Impact involving the community in entomological surveillance of the Triatoma infestans vectorial control

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Research

Keywords: Triatomines, kissing bugs, Chagas disease, community participation

Posted Date: October 23rd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-93406/v1

Version of Record: A version of this preprint was published on February 5th, 2021. See the published version at https://doi.org/10.1186/s13071-021-04608-6.

Abstract

Background

Vectorial transmission is the principal way of *Trypanosoma cruzi* infection, the parasite that cause Chagas disease. In Argentina, *Triatoma infestans* is the principal vector, for this reason, vector control is the main strategy for the prevention of this illness. Provincial Program of Chagas La Rioja (PPCHLR) carries out entomological evaluation of domiciliary units (DU) and spraying those where *T. infestans* are found. The lack of government funds generated low visit frequency of PPCHLR, especially in areas with a low infestation that they were not prioritized. For this reason, seeking possible alternatives to complement control activities are necessary. Involving householders in entomologic evaluation would be a control alternative. The major objective was to determine the cost of entomological evaluation with and without community participation.

Methods

For entomological evaluation without community participation, PPCHLR data collected in February 2017 over 359 DU of Castro Barros Department (CBD) were used. For entomological evaluation with community participation, 434 DU of the same department were selected in November 2017. Each householder was trained in the insect collection that were kept in labelled plastic bags and recovered after two weeks to analyse *T. cruzi* presence in laboratory. Entomological evaluation costs with and without community participation over DU visited number, over DU evaluated number, and over DU sprayed were calculated and compared between methodologies. In addition, DU evaluated number out DU visited number was compared.

Results

The results showed that the triatomines did not show evidence of *T. cruzi* infection. Costs in relation to DU visited, to those evaluated and to those sprayed, were lowered with community participation ($p< 0.05$). In addition, a greater number of DU evaluated in relation to those visited as well as greater surface were covered with community participation.

Conclusion

The participation of the community in the infestation survey is an efficient complement of vertical control, allowing the spraying to be focused on infested houses and thus reducing costs and intervention times by PPCHLR.

Background

Chagas disease continues to be an important public health problem in Latin America where it is estimated that there are between 6 and 7 million people infected with the *Trypanosoma cruzi* parasite, the causative agent of this disease [1]. In Argentina, it is assumed that there are between one to three million people who could have this disease, although there are currently no official data on the number of people infected or at risk of *T. cruzi* infection [2].

This parasite can be transmitted through different ways, although in 80% of cases it is through vector transmission, that is, by contact with triatomines, so the control of this infestation is the main strategy for the prevention of the illness.

In Argentina, *Triatoma infestans* is the triatomine species with the greatest epidemiological importance, given its ability to inhabit within and on houses periphery. La Rioja province is endemic for Chagas disease, considered of medium risk in the transmission of this disease by *T. infestans* [3]. Provincial Program of Chagas La Rioja (PPCHLR) works on entomological evaluation and insecticide spraying in positive houses to eliminate *T. infestans* infestation, without considering householder denouncement, ensuring that the negative houses do not receive treatment. For entomological evaluation of houses, the PPCHLR staff moves from the Capital city to the different departments and returns to them depending on political decisions over economic resources derivation. For this reason, PPCHLR focalizes surveillance in departments with a high infestation. Castro Barros Department (CBD) has been low frequency in vector control intervention in part, it is a consequence of a lower *T. infestans* infestation in relation to others that have been a priority for PPCHLR, such as, San Martin Department [4, 5]. It is known that higher intervention interval favours the risk of *T. infestans* populations' recover [6]. At the same time, the community demand vector control activities due to the frequent *T. infestans* presence because it is impossible to consolidate control and surveillance actions with vertical strategy methods in extended rural areas [7]. Therefore, in this area, community participation in entomological surveillance would be an essential tool given this complex scenario but the cost of this type of control activity needs to be evaluated. Entomological surveillance carried out by the householders has been described by several authors and community participation favour the early detection of triatominos [e.g.8,9,10,11,12,13,14,15,16]. In addition to the fact that householder collection of triatomines may be more sensitive than active search in some areas [10, 13, 17], especially when the infestation is of low density [12].

This study was originated within a greater project in response to the community's demand to our research team that reside in CBD. The main objectives of this work were: to determine the cost of vectorial control activities with and without community participation; and to analyse the spatial distribution of the *T. infestans* infestation in the study area.

Methods

Study area:

CBD is located to northeast of La Rioja province, Argentina. Its departmental head is the Aminga locality, distant 95 km of the capital city. It is located in the biogeographic region of Monte Desert. The population density is around 3 inhabitants / km^2. It is a rural population, concentrated in 10 localities that function as an oasis due to the availability of surface water. Total population of CBD is 4268 inhabitants [18].

About domestic infestation, between 2009 and 2013 ranged between 1.18% and 9.87%. In 2013, the latest departmental intervention was carried out by PPCHLR, that is, without community participation (PPCHLR unpublished data).

Each intradomicile (ID) with their peridomestic structures (PD) was defined as domiciliary unit (DU). A DU was recorded as “infested or positive” when at least one *T. infestans* individual was found in the DU.

Entomological evaluation without community participation

In February 2017, 359 DU localized in Aminga (one of ten localities of department), were visited for entomological evaluation, carried out by 20 PPCHLR technicians. In the search was used dislocating agent (tetramethrin 2%) and it was interrupted when insect was found or until an hour of capture effort is completed (hour / man method). Infestation status and treatment of each georeferenced DU were registered. This type of control was defined as vertical intervention.

DU evaluated was defined as that DU in which householder was present and approved entomological evaluation while DU visited is defined as all DUs, included those in which householder was not present at the moment of entomological evaluation carried out by PPCHLR technicians.

Entomological evaluation with community participation:

In December 2017, 434 DU corresponding to nine localities of CBD (Fig. 1) were visited and *T. infestans* infestation was evaluated by householders [13].

The samples was selected considering the total number of DU in each locality (Table 1), covering the total area.

ble 1 Description of the study area for each locality.

Locality	Total number of DU[a]	Inhabitants number[b]	Altitude (masl)	Number of DU visited	Coverage (%)[c]
San Pedro	145	298	1507	16	11
Santa Vera Cruz	79	123	1323	16	20
Anjullon	242	418	1294	42	17.36
Los Molinos	166	244	1254	35	21
Anillaco	678	1573	1325	110	16.22
Aminga	359	833	1275	99	27
Chuquis	157	236	1323	44	28.03
Pinchas	262	390	1351	55	20.99
Agua Blanca	30	68	1470	17	56.7

a. Local hospitals database.

b. INDEC. Instituto Nacional de Estadística y Censos. 2010.

c. Coverage is calculated as number of DU visited over DU total number.

Inhabitants of the selected DU received a detailed explanation of the study and were invited to participate. Inhabitants that accepted the invitation were trained in triatomines identification, in places that should look for and careful collection to avoid the risk of accidental infection. Each participating family received plastic bags labelled with the DU identification code for different ecotopes. A registry was made with the participating families and the characteristics of their DU. Householders' collection lasted two weeks between November and December 2017 (from delivery to plastic bags collection). At the same time, health agents from local hospitals worked alongside householders.

The collected bags were transferred to the laboratory where species, gender and developmental stage [19] were determined and *T. cruzi* detection was performed in rectal material. *T. infestans* number by gender and sex was quantified for each locality. For *T. cruzi* analysis, the faecal samples were examined fresh in a drop of physiological solution in an optical microscope at a magnification of 400x for approximately 15 minutes (25 fields). *T. infestans* presence registered in each DU was notified to PPCHLR for pyrethroid insecticide treatment.

DU visited is defined as that DU selected in which householder was given bags for insect collection.

DU evaluated was defined as that DU in which householder gave us bags with or without material. DU closed was defined as that DU in which householder was not present at bags collection moment.

Costs with and without community participation

To determine the cost of vectorial control activities with and without community participation, CBD campaign countable information given by PPCHLR were used (February and December 2017).

Cost without community participation was only constituted by the 'expenses' (fuel and travel wage) incurred by PPCHLR.

When householders participated, cost was constituted by the sum of the 'expenses incurred by PPCHLR and inputs used (brochures and gloves).

The cost over DU visited number, over DU evaluated number and in relation to DU sprayed number were calculated for each methodology.

The insecticide and spraying machine costs were not considered since they were the same for each methodology. In both cases, the supplies to carry out spraying were provided by National Chagas Program and did not imply an additional cost for PPCHLR.

Climatic Variables

To verify the climatic conditions in the study area and based on equipment availability, three data loggers (HOBO U10 / 003 Onset Computer Corporation, Bourne, MA, USA), each of them were placed in Pinchas, Anillaco and Santa Vera Cruz localities (Fig. 1). Temperature (°C) and relative humidity (%) were recorded at 15-minute intervals between 7:00 p.m. and 10:30 p.m., corresponding to the moment of the peak active dispersion for *T. infestans* [20, 21, 22].

Data analysis:

The percentage of infested DU was calculated over total evaluated DU by locality.

For cost analysis, data were compared between methodologies using Chi-Square of Infostat program [23].

A spatial scan statistic with a Poisson model was used to detect clusters (groups of localities geographically aggregated and with higher or lower infestation compared with the regional average). Locality was the analysis unit. Analysis was performed using SaTScan v. 9.4.4 [24].

Climatic variables were compared with a non-parametric Kruskal-Wallis test using the Infostat program [23].

Results

In February 2017, DU infestation was 8.26% (1/109 ID and 8/109 PD) of which all were sprayed.

In December 2017, a total of 81.6% DU were evaluated (354/434) by householders, due to the fact that 18.4% of DU were closed. The general infestation by *T. infestans* in the study area was 13.8%, varying between 0 and 50% among localities (Table 2). A total of 97.4% positive ID (1/39) and 40% positive PD (4/10) were sprayed by PPCHLR technicians with pyrethroid insecticide.

Table 2
Infestation by *T. infestans* obtained by householder collection in Castro Barros Department, La Rioja.

Locality	DU evaluated	DU closed [a]	DU Infestation% (CI 95)	Number of ID with *T. infestans* presence [b]	Number of PD with T. infestans presence [c]
San Pedro	12	4	8.33 (0.44–40.25)	1	0
Santa Vera Cruz	13	3	0 (0-28.34)	0	0
Anjullon	36	6	0 (0–12.00)	0	0
Los Molinos	27	8	14.81 (4.86–34.61)	1	3
Anillaco	84	26	8.33 (3.7-16.95)	7	0
Aminga	73	26	5.48 (1.77–14.16)	4	0
Chuquis	41	3	12.19 (4.58-27.00)	4	1
Pinchas	52	3	38.46 (2.56–52.99)	15	5
Agua Blanca	16	1	50 27.99-72.00)	7	1

[a] DU closed at the moment of bags collection

[b] ID: Intradomicile

[c] PD: Peridomicile

Householders collected 79 specimens of *T. infestans* (Fig. 2), 52 individuals in ID and 27 in PD. None with presence of *T. cruzi* infection. *T. infestans* number collected between localities could not be compared because collection time per householders is not standardized.

When the costs were compared between methodologies (Table 3), data showed a reduction in costs related to DU visited ($\chi^2 = 4.57$, $p < 0.0325$), to those evaluated ($\chi^2 = 24.64$, $p < 0.0001$) and to those sprayed ($\chi^2 = 13.22$, $p < 0.0003$) with community participation. Moreover, a greater number of DU evaluated in relation to those visited ($\chi^2 = 23.43$, $p < 0.0001$) as well as a larger surface covered (163.9 vs. 0.8 km2) were obtained with community participation.

Table 3
Comparisons of indicators between methodologies in Castro Barros Department during 2017

Variables	**Entomological Evaluation by PPCHLR, without Community Participation (Feb)**	**Entomological Evaluation with Community Participation (Dec)**
Number of DU visited	359	434
Number of DU evaluated	109	354
Number of DU sprayed after evaluation	57	43
Surface evaluated (km^2)	0.796	163.89
Cost	3809.90	1323.71
Cost over the number of DU visited	10.61*	3.05*
Cost over the number of DU evaluated	34.95**	3.74**
Cost over the number of DU sprayed	66.84***	30.78***
*χ^2=4.57, $p < 0.0325$; **χ^2=24.64, $p < 0.0001$; ***χ^2=13.22, $p < 0.0003$		

Table 4
Median of temperature (°C) and relative humidity (%) for each cluster (Quartiles 1 and 3).

Cluster	Variable	Median	Quartile 1	Quartile 3
North Zone	Temperature	22.33	20.42	24.84
	Relative Humidity	52.53	42.67	62.44
Centre Zone	Temperature	26.68	25.42	28.16
	Relative Humidity	40.03	34.01	45.94
South Zone	TemperFature	28.06	26.98	29.45
	Relative Humidity	35.82	30.64	38.38

The spatial analysis allowed to detect differences in the infestation with respect to average in the area. Three clusters in the area were identified. The first cluster called North Zone, presented an infestation of 0.02%, that is, less than the average in the area (Relative risk = 0.1; p = 0.02) and covered three localities, San Pedro, Santa Vera Cruz and Anjullón, with 61 DU and with a radius of 6.33 km centred on -28.66°S, -66.92°W. The second localities grouping in a cluster, called Centre Zone, presented an infestation of 0.07% also lower than expected (Relative risk = 0.37; p = 0.04) with two localities, Aminga and Anillaco, with 157 DU and with a radius of 4.68 km centred at -28.85° S, -66.93° W. The third cluster, called South Zone, with an infestation of 39.7%, higher than expected (Relative risk = 5.4; p < 0.001) that covered two localities, Agua Blanca and Pinchas, with 68 DU and a radius of 4.88, centred on − 28.96° S, -66.99°W. (Fig. 3).

As possible factors that could influence the zonal infestation differences, temperature and relative humidity were compared among clusters. South Zone had a higher temperature than Centre Zone, and this, in turn, had a higher temperature than North Zone (H: 96.73, gl:2, p < 0.0001). In relation to relative humidity, South Zone showed lower humidity than Centre Zone, and this in turn showed lower humidity than North Zone (H: 59.51, gl: 2, p < 0.0001). Table 4 shows the median temperature and relative humidity.

Discussion

The control of *T. infestans* infestation is the main strategy for the prevention of Chagas disease in Argentina. When vector control actions are carried out in a sustained and committed way over time, triatomines presence in houses is reduced and consequently, the risk of vector transmission decreased. However, in areas where the infestation is reduced, a paradox occurs as these areas lose surveillance priority and are visited less and less frequently, and their chemical treatments are postponed [12, 25]. This misconception produces a huge setback to achieve the main objective, which is the vectorial transmission interruption. For CBD, entomological evaluation frequency is greater than three years and, at each visit, evaluation coverage is reduced due to political decisions that limit PPCHLR logistic and budget.

Theoretical vertical vector control model would be annual intervention by specialized technicians who evaluate and spray houses [25]. In fact, this logistical capacity does not exist in La Rioja province. Given the actual situation, advantages and disadvantages of maintaining only vertical PPCHLR interventions in low infestation areas are necessary to be re-evaluated.

In this work, the impact of incorporating community participation in areas with a low domestic infestation that in general are neither focus of study nor priority to apply vector control actions is analysed. The low frequency with a vertical program cannot meet demand in areas where infestation risk is known to be low [5, 7], causing the domestic vector persistence to continue and recovering populations among spraying cycles [6, 26]. Incorporating participatory approaches against vector-borne diseases has been shown to be important for control program sustainability [9, 11, 13, 26, 27, 28, 29, 30]. Periodic inspection allows the early detection of new foci of reinfestation in the intradomicile [15, 17, 31]. Although, bio-eco-social approach not always reduce the infestation by itself [32]. In addition, one of the main criticisms of the incorporation of community participation in health programs refers to the process and place that is provided to the community in the construction of decision-making [25]. Different people bring different assessments to a situation and these must be taken into account [33]. In this study, community intervention was focused in the surveillance phase to guarantee early triatomines detection. Furthermore, it promoted an active and positive attitude in local population and the householders were able to clarify their doubts related to the transmission and prevention of Chagas Disease.

In this work, using field data collected in the same year and without modelling on indirectly estimated variables, two intervention types were compared, showing that costs in relation to DU visited, evaluated, and sprayed were lowered with community participation. In addition, a greater proportion of DU evaluated in relation to those visited as well as greater surface were covered with community participation. There are many works showing a cost decrease when community collaborates in surveillance [11, 17, 30, 34, 35, 36, 37] although with completely different approaches that do not allow a direct comparison with our data. For example, in Mexico, the cost to evaluate entomologically a domicile, detecting *T. dimidiata*, was US$70 for an infested house by carrying out an active search and only US$10 when householders were involved [17]. Also, in Santiago del Estero (Argentina) a very complete analysis was carried out, considering community intervention and the cost-effectiveness was estimated in attack phase where householders sprayed owns houses [11]. These latter results would not be comparable to our data since our focus is only on entomological surveillance and the spraying is only carried out by specialized personnel.

In La Rioja province, it is assumed that a house should be sprayed when PPCHLR technicians corroborate *T. infestans* presence. PPCHLR searching is carried out during the day, however, the householders can be carried out it during the day and at night. In this case, the probability of finding dispersants is higher due to the *T. infestans* peak activity occur between 7 and 10 pm [20]. Our results showed that most of the insects collected by householders were found in ID (52/79), which 13.5% (7/52) were found on the external wall, light or in the mosquito netting, so it is assumed as dispersants from other sources. For this reason, it is important to establish an appropriate response to each *T. infestans* collected by a householder. Especially, if *T. infestans* is a female, represents a particular epidemiological risk as colonizers of houses, justifying a control intervention. It is known that each fertilized female can lay between 100 and 600 eggs in her lifetime [38]. Dispersant females carried numerous eggs within the oviducts to ensure successful colonization of a new habitat [21], so it is necessary not to postpone control actions. In the case of triatomines dispersant collection, the possibilities of invasion can be reduced by physical protection (such as mosquito netting) [25].

In order to control circuit function correctly, we proposed that householders inform about the *T. infestans* presence in their houses and notify to Municipality. For this, is necessary that each Department count on a municipal referent verifies this species presence. If houses are *T. infestans* positive, personnel designated for this purpose spray them and their surroundings. Although, in this particular context, our CRILAR medical entomology team participates in a social commitment, it is expected that this activity should be carried out routinely by health area staff or Chagas municipal referent implying that there would be no extra costs. In this way, technician work is optimized, focusing the spraying on positive houses already surveyed by sanitary agents, while, at the same time, reducing travel wage and fuel costs for the transfer of PPCHLR personnel to field. These economic resources would be designated to increase the treatment frequency PPCHLR over higher infestation areas. To understand the variables associated with infestation in the area help in design of entomological surveillance implementation [25].

Heterogeneity in infestation probability is known in areas of Gran Chaco [4, 5, 13, 34, 39]. In addition, *T. infestans* domestic infestation estimated with community participation allowed to detect a spatially heterogeneous infestation in CBD.

Within this department, southern zone presented the highest risk of infestation. Heterogeneity in the infestation risk could be associated to climatic conditions due to southern zone presented higher temperature and lower humidity in relation to the other ones. These climatic conditions could allow an optimal growth of the species as was observed by other authors [34, 40, 41]. Although the climatic variables ranges in the different zones would be within their optimal values, the zone with the highest temperature and lowest humidity would provide a better development of *T. infestans* populations. It is known that optimal levels for most of triatomines are temperatures of 26–29 °C and 70% or less of relative humidity. When temperatures are higher at this range, insects need higher humidity to prevent dehydration. If the climate conditions are not enough wet, the dehydration danger can only be solved by increasing the blood meals number, producing a life cycle reduction with a population increase [42]. Another factor that could explain zonal differences was the PD presence due to those gave refuge and feeding sources for triatomines [43]. In southern zone (Agua Blanca and Pinchas), PD with *T. infestans* presence in DU evaluated (6/22) was observed, not so in the north and central zones (Table 2). All these results showed that there are several factors that promote *T. infestans* presence, particularly in this zone.

An orderly and efficient entomological surveillance system is necessary in rural areas far from the capital, since otherwise the feasibility of maintaining a successful chemical control diminishes.

This work allowed to verify that involving community in entomological surveillance reduced costs, covered a greater surface and a proportion of DU evaluated, encouraged early infestation detection and is the first step in stimulating control interventions. However, for this strategy to be effective, municipalities should carry out sustained surveillance work and chemical control interventions to prevent *T. infestans* populations from recovering after an application interval. Therefore, these actions must continue to be encouraged and, in addition, the authorities must be committed to giving a quick and effective response to householder demands.

Conclusion

Community participation is recommended in low infestation areas where a vertical control strategy difficult an adequate control frequency. This strategy is an efficient complement of PPCHLR technicians, increasing collection coverage, allowing the spraying to be focused on infested houses, and thus, reducing costs and intervention times by PPCHLR, integrating easily with other health programs.

Abbreviations

PPCHLR: Provincial Program of Chagas La Rioja

CBD: Castro Barros Department

DU: Domiciliary Unit

ID: Intradomicile

PD: Peridomestic structures

Declarations

Acknowledgements:

To C. Nieto for collaborating in the field and laboratory activities, to householders of Castro Barros department, to Health Center of Pinchas and Los Molinos and their sanitary agents, to the technicians of the Provincial Program of Chagas La Rioja, to C. Gonzalez in surface estimation of the study, to L. Fiorelli for figure assistance, to V. Valentinuzzi for her support in general research aspects and for providing dataloggers. We thank anonymous reviewers for insightful comments that improved the final version. LA, MJC and IA are CONICET members.

Funding:

Financial support was received from Argentinean National Council for Scientific Research (CONICET), grant PUE 0125 and Argentinean National Agency of Science and Technological Promotion (FONCyT) grant PICT 2016-0512 to L.A.

The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article. Raw data are available from the corresponding author on reasonable request.

Authors' contributions

LA, MJC and IA carried out the field and lab works, conceptualized and designed the study. LA drafted the manuscript; carried out statistical analyses and provided financial support. MJC and IA carried out statistical analyses and helped draft the manuscript. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable.

Competing interests

The authors have declared that no competing interests exist.

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Figures

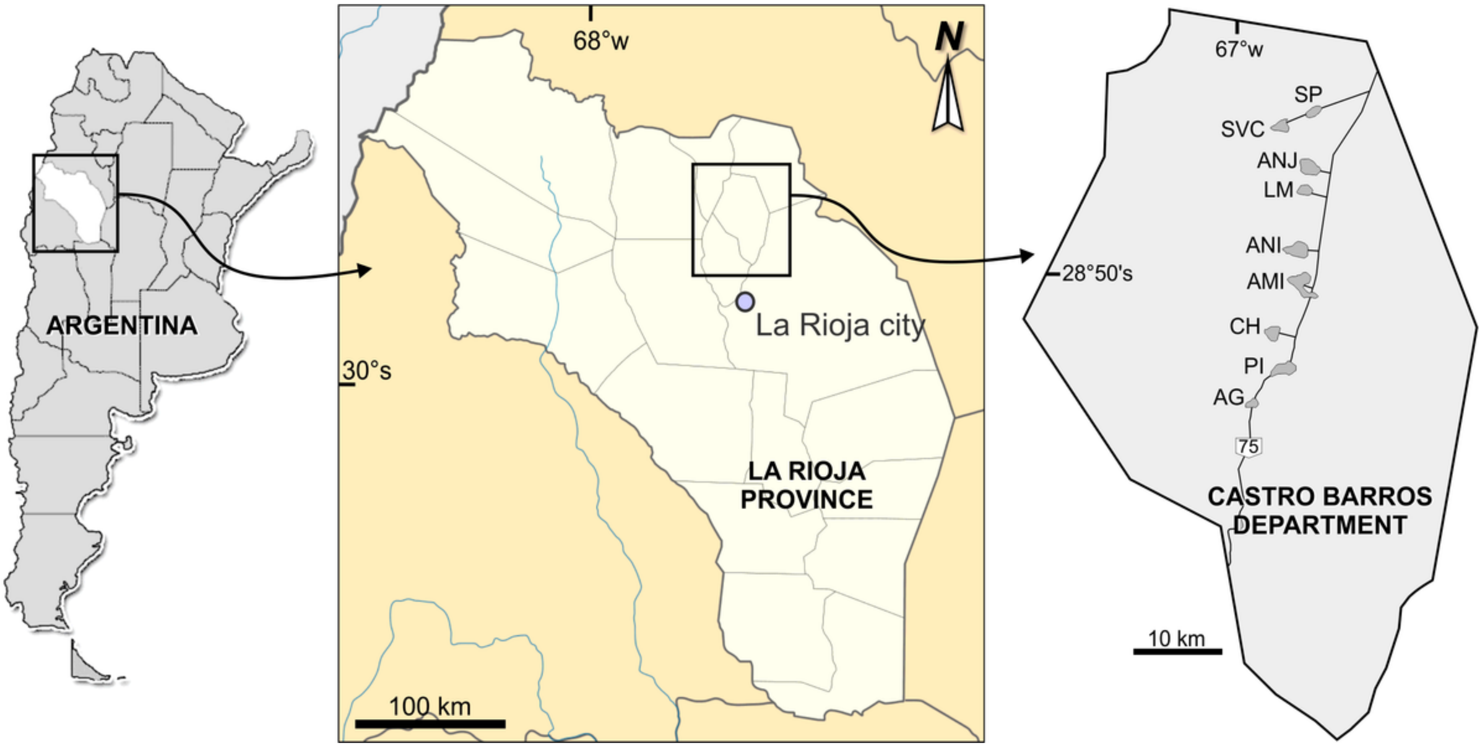

Figure 1

Geographical localization of Castro Barros Department and localities evaluated with community participation in December 2017. SP: San Pedro, SVC: Santa Vera Cruz, ANJ: Anjullón, LM: Los Molinos, ANI: Anillaco, AMI: Aminga, CH: Chuquis, PI: Pinchas, AG: Agua Blanca.

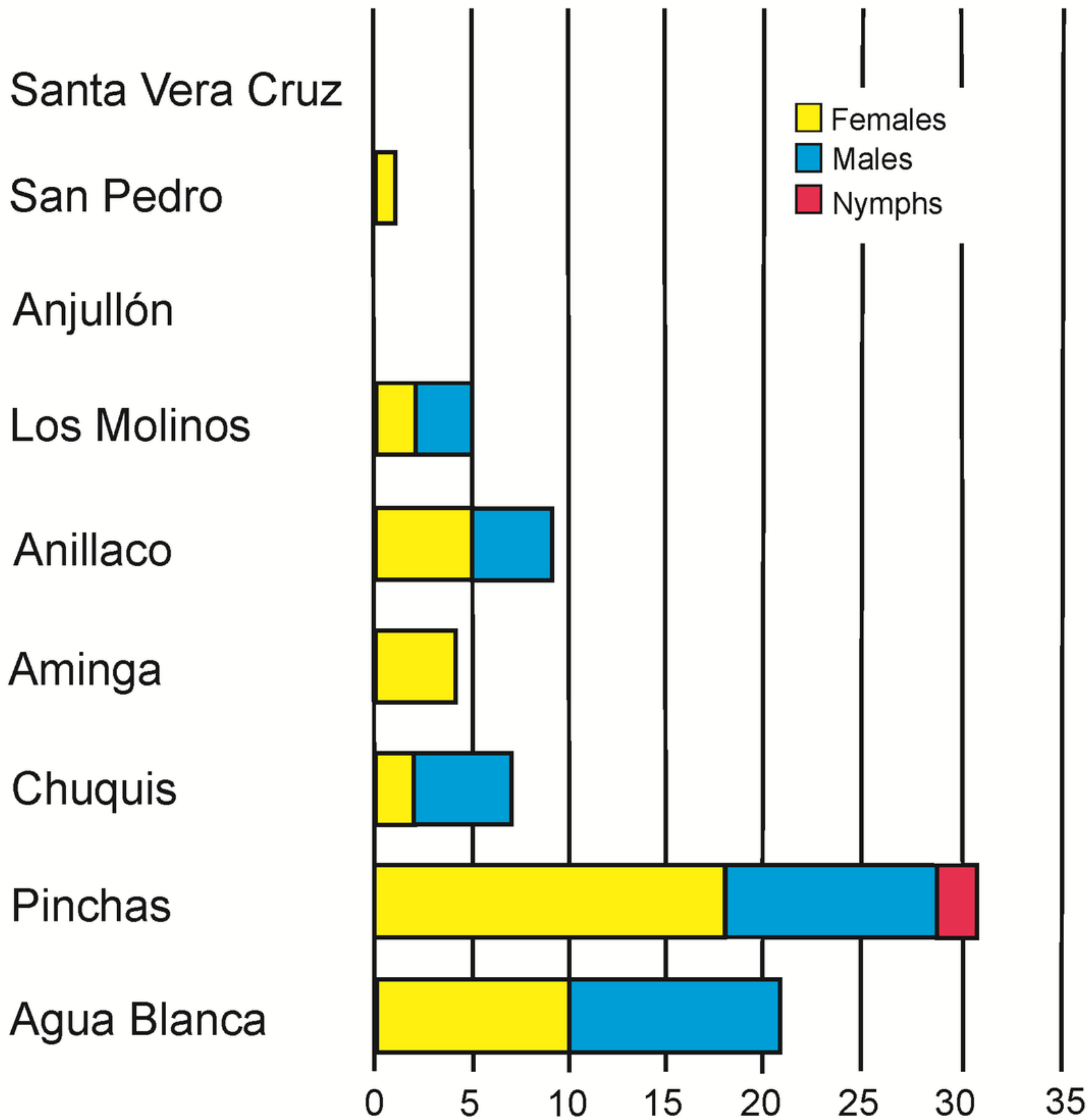

Figure 2

T. infestans number collected by developmental stage and gender in localities evaluated with community participation.

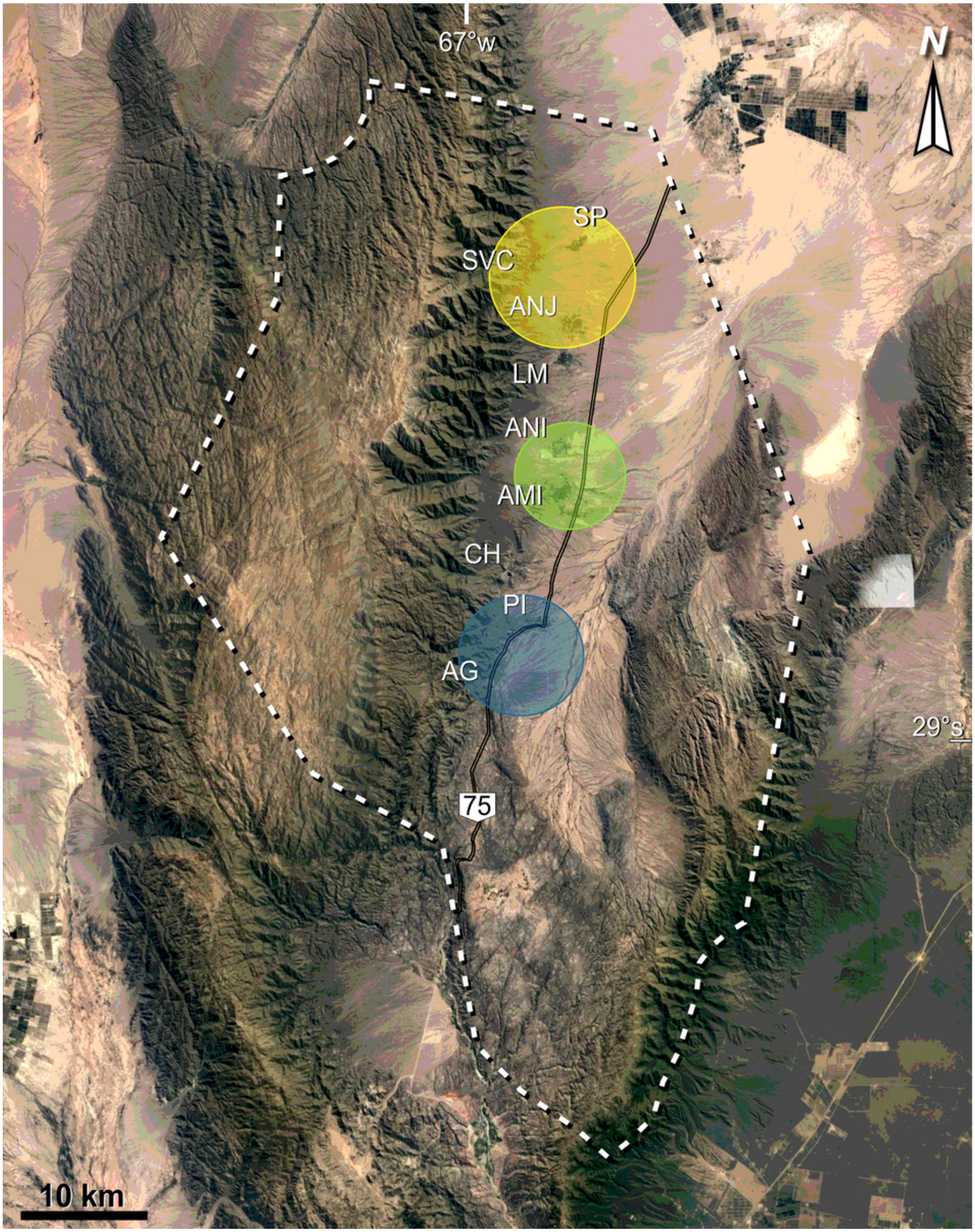

Figure 3

Clusters of localities with high and low infestation by T. infestans in Castro Barros Department. Entomological evaluation with community participation in December 2017. Each circle represents cluster area and groups localities with similar T. infestans infestation. North Zone Cluster (Low infestation = 0.02%). Centre Zone Cluster (Low infestation =0.07%). South Zone Cluster (High infestation =39.7%). SP:

San Pedro, SVC: Santa Vera Cruz, ANJ: Anjullón, LM: Los Molinos, ANI: Anillaco, AMI: Aminga, CH: Chuquis, PI: Pinchas, AG: Agua Blanca.